PH Craftsman Course
CFSP Review

FOOD Chemistry

and

MICROBIOLOGY

OVERVIEW

- Food Spoilage
- Factors affecting microbial growth in foods
- Microbial growth (and death)
- Foods supporting microbial growth
- Food additives
- Prevention/Control of food pathogens

Spoilage Microbes in Foods

- What is food spoilage?
- Bacteria
  - The Lactic Acid Bacteria (*Lactobacillus* spp., *Pediococcus* spp., *Leuconostoc* spp., etc.)
  - *Pseudomonas* spp.
  - Many others
- Fungi
  - Molds and Yeast

- What about viruses?
- Many spoilage microbes grow well at refrigeration temperatures
- Lactic Acid Bacteria, Molds, and Yeast are not all bad--can be used in food production

Spoilage Microbes--How Did They Get There?

- Contamination pre-harvest
- Contamination during processing
- Fungi and bacteria are everywhere!

Other Causes of Food Spoilage

- Microbial spoilage is not the only cause of food quality deterioration
- Chemical reactions can also reduce food quality
  - Exposure to air or light (oxidative rancidity)
  - Reactions caused by enzymes in the food leading to off-flavors
  - Other chemical reactions/interactions
- Cold storage temperatures can minimize chemical reactions

Factors Affecting Microbial Growth in Foods

What are the factors affecting microbial growth in foods?

F-

A-

T-

T-

O-

M-

(P)-

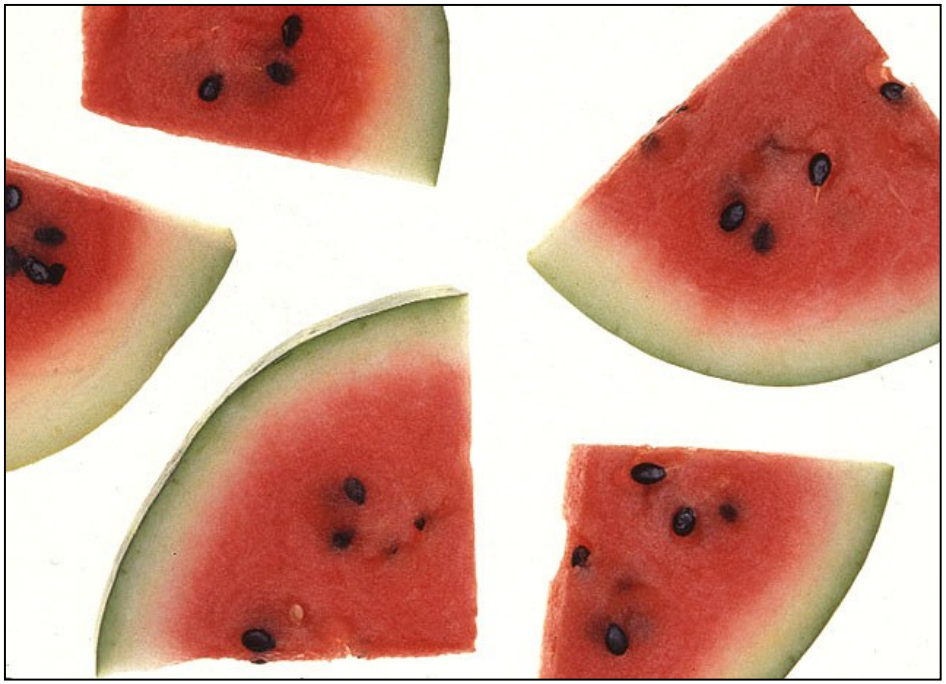
F ("Food" for the microbes to eat)

Nutrients in food affect microbial growth:

- Sources of energy (e.g., sugars, proteins)
- Sources of nitrogen (e.g., proteins)
- Vitamins
- Minerals

In order for bacteria to grow, the food has to have the right nutrients for the bacteria *and* the bacteria have to be able to "get to" the food...

- So the “biological structure” of the food is important:
  - Plants have outer “skins” which protect them from microbial growth
  - What happens when the skin is damaged (or cut into like this watermelon)?



Acid (pH)

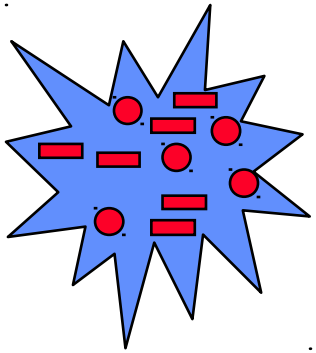
- Microorganisms grow best at pH near 7
  - As the pH goes lower, if microorganisms grow, they grow slower
- *Most pathogens do not grow or at least don't grow well at pH < 4.6*
  - However, they may *survive* at least for a short time at low pH
- Many yeast, molds, and spoilage bacteria can grow at pH < 4.6
  - Why is this important?

Temperature and Time

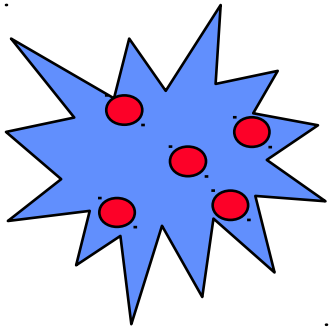
- Classifying bacteria by growth temperatures:
  - Thermophiles(very hot)
  - Mesophiles (cool to very warm or hot)
  - Psychrotrophs (cold or warm)
  - Psychrophiles (only cold)
- In food microbiology, we are most concerned with mesophiles and psychrotrophs

- Refrigeration (≤ 41°F)
  - Slows *or* stops pathogen growth
  - Most pathogens don't grow in refrigerated foods
  - However, a few pathogens can grow **slowly** under refrigeration (they are psychrotrophs)
    - *Listeria monocytogenes*
    - *Yersinia enterocolytica*
    - *Aeromonas hydrophila*
    - *Clostridium botulinum* type E
  - Many spoilage microbes are psychrotrophs
- Freezing does not kill bacteria
  - Some may die when frozen, but this can't be counted on

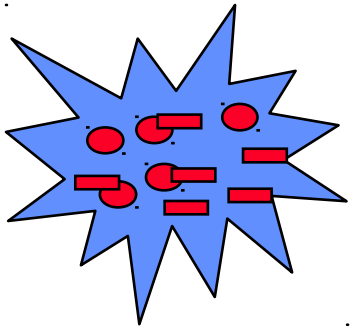
- Heat
  - Cooking to ≥ 165°F kills most pathogens
    - Remember which ones aren't killed/destroyed?
      - Spores, toxins
  - If food is held on a hot serving line at ≥ 140°F, pathogens can NOT grow or produce toxins



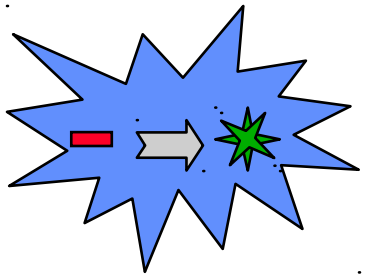
Food with vegetative cells and spore cells



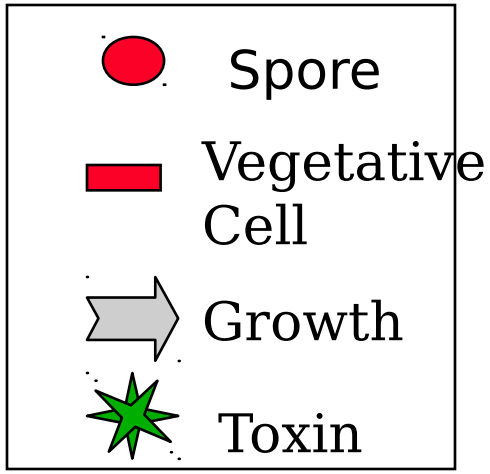
Only spores survive when food is heated (cooked) to 165 °F and then held ≥140°F



Spores can become vegetative cells again if food is not cooled properly



Vegetative cells grow to high numbers and some produce toxins



- Many bacterial pathogens need time to grow to high enough levels or produce enough toxin to cause disease (4 hrs in the danger zone)
- One of the most common factors leading to foodborne illness is improper cooling of leftover foods!
  - Where do foods cool faster--on the counter or in the refrigerator?

“Food Safety Thermometer”

Keep hot foods hot

140°F

Danger Zone = **Temperature range of rapid pathogen growth**

41°F

Keep cold foods cold

Oxygen (Oxidation-Reduction Potential)

- O-R potential generally refers to the amount of oxygen present
- Pathogens:
  - Most bacterial pathogens can grow with or without Oxygen (*Facultative anaerobes*)
  - Some food pathogens can only grow when no Oxygen is present (*anaerobes*)
    - Example?

- Spoilage microorganisms:
  - Obligate aerobes:
    - *Pseudomonas* spp.
    - Molds
    - How do you think food processors use this information about obligate aerobe spoilage microbes?
  - Microaerophiles:
    - Lactic Acid Bacteria
  - Anaerobes
    - *Desulfotomaculum* spp. (food processing concern--can spoilage)
    - Others

Moisture (water)

- Why is water important to bacteria?
  - To survive?
  - To grow?
- Is it the total amount of water present in the food that's important?
- Water in food is present in two forms:
  - BOUND
  - FREE
- Bound water is unavailable for bacteria to grow

Water Activity (A_W)

- A measure of the FREE WATER--water that is available for microbial growth
  - A_W is simply the Relative Humidity of the food (at equilibrium with the air around the food)
- A_W can range from:
  - 0.00 (no free water) to 1.00 (all free water)
- We don't usually measure A_W values in the Air Force, but you can look them up in food microbiology books

A_w	Foods (some examples)
0.98 to 1.00	Fresh meats, fruit, vegetables, canned fruit in light syrup, canned vegetables, beverages
0.93 to 0.98	Processed cheese, bread dough, lightly salted meats (e.g., hot dogs), canned fruit in heavy syrup
0.85 to 0.93	Ham, aged cheddar cheese, most bread, dry sausage, sweetened condensed milk
0.60 to 0.85	Flour, cereals, jams/jellies, nuts, some cheese, heavily salted foods, dried fruit
<0.60	Chocolate, honey, noodles, crackers, potato chips, dried milk, dried vegetables

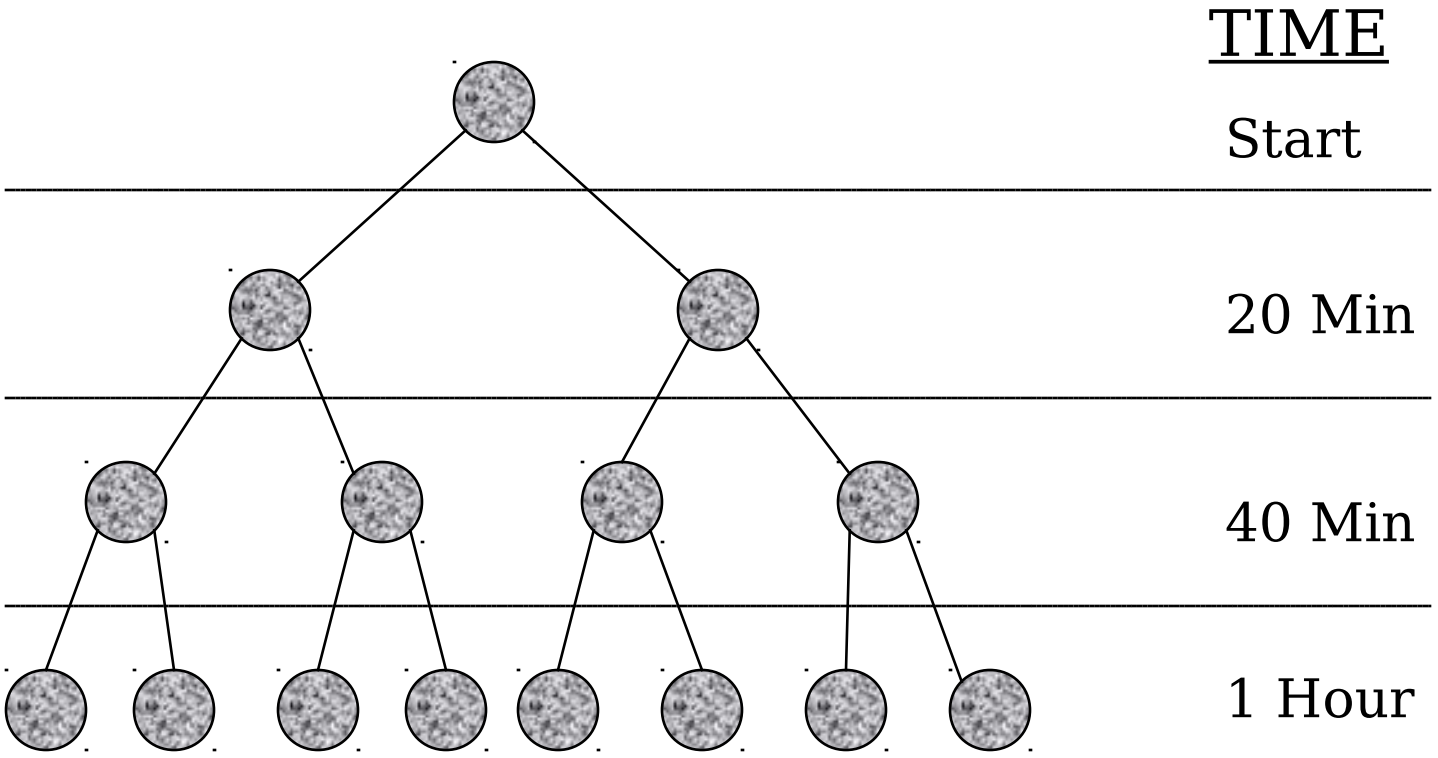
***Pathogens do not grow or produce toxins at $A_w < 0.85$**

Adapted from APHA, Compendium of Methods for the Microbial Examination

- **Most bacterial pathogens can not grow or produce toxins at A_W < 0.91**
  - Exception: *Staph. aureus* can grow and produce toxin down to 0.85
- ***How do you think A_W can be decreased?*** **1. 2. 3.**
- ***How do these methods work?***

How Long do Bacteria Need to Grow?

- Under ideal conditions, some bacteria can double in number every 15-30 minutes
  - Example: bacteria with a 20 min doubling time:

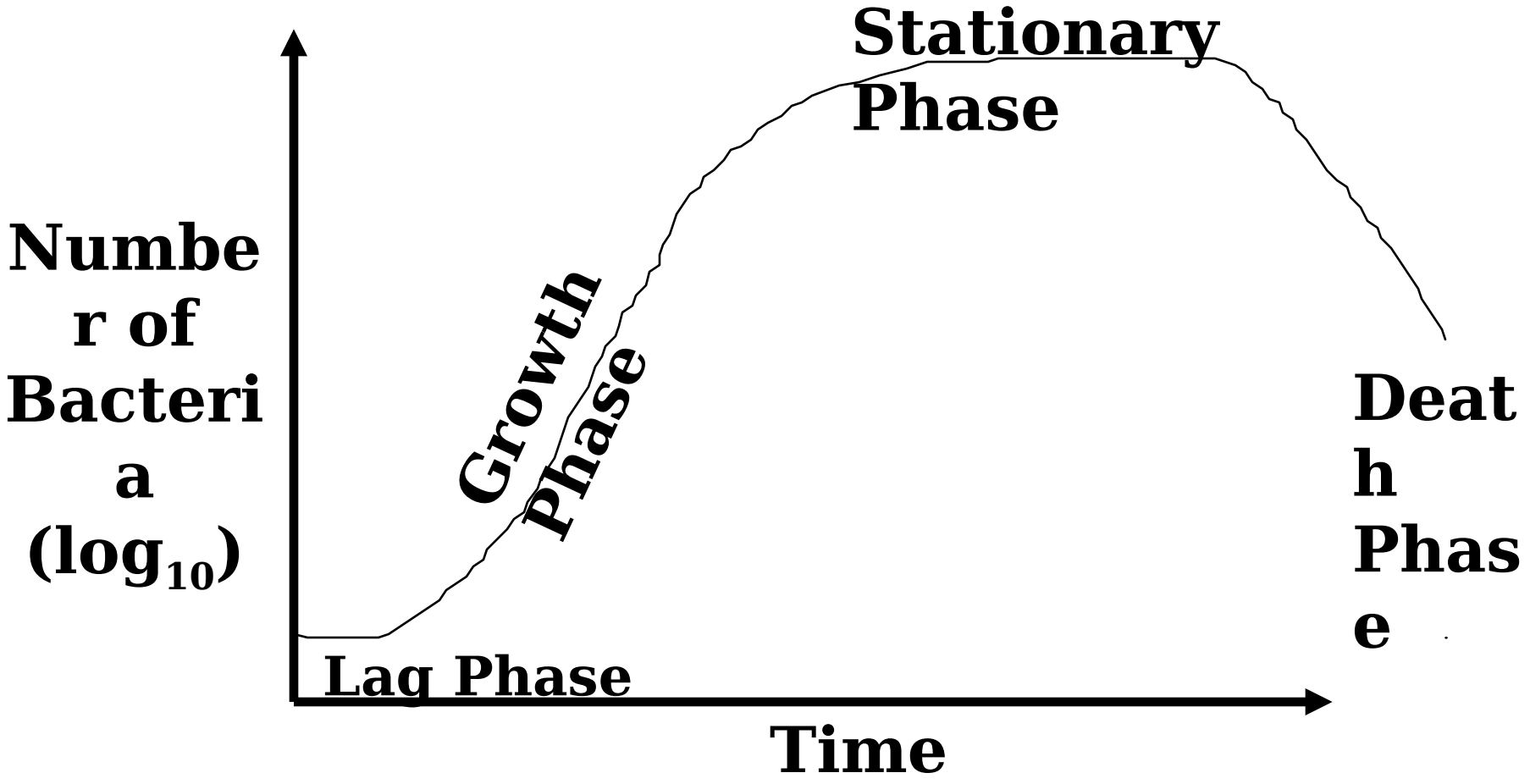


Exercise:

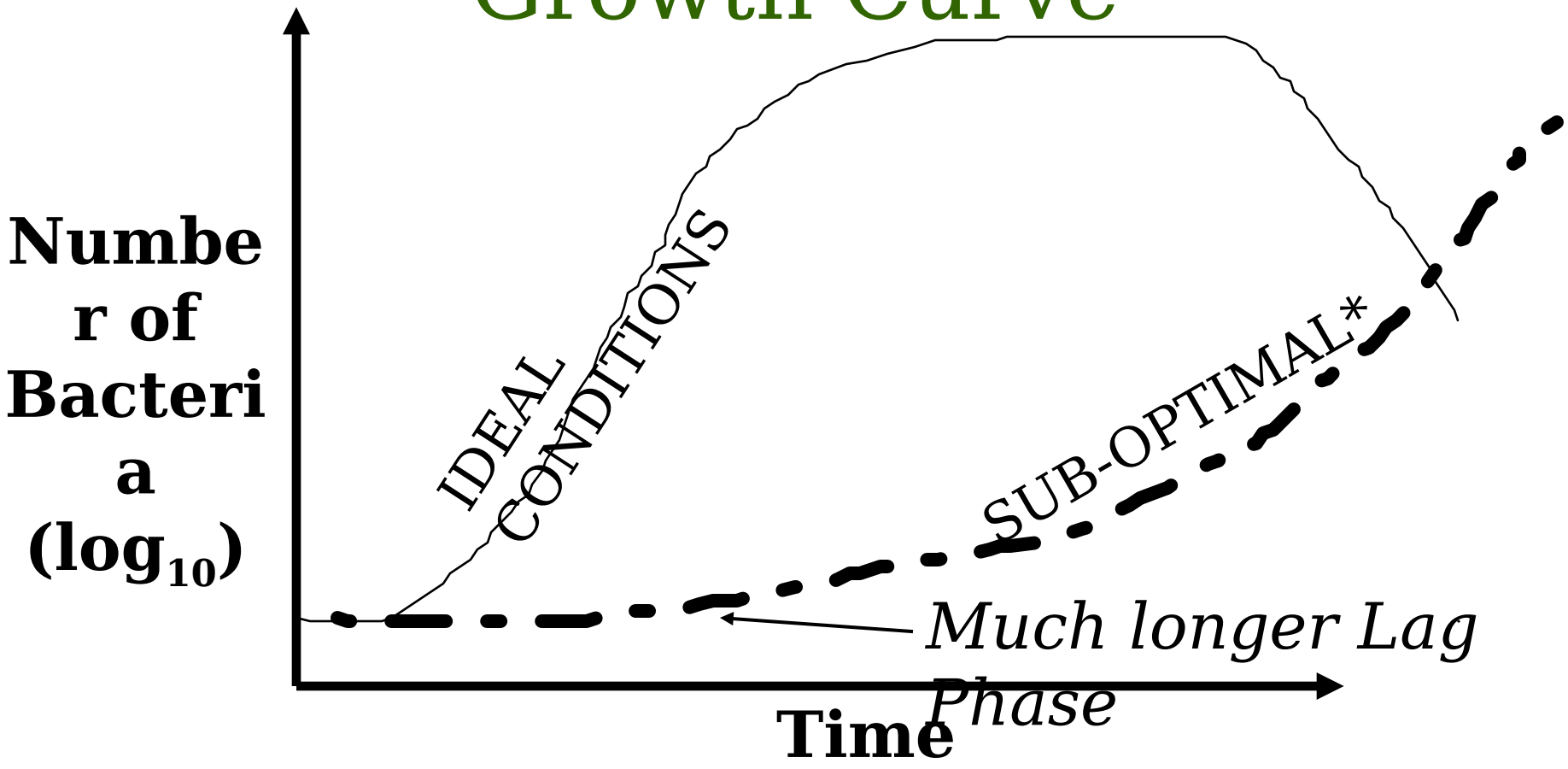
(Assume 20 min. doubling time)

- 1 bacteria on a hamburger sitting at 90F.
- How many bacteria after 1 hr? 4 hrs? 8 hrs?
- What if there were 10,000 bacteria to start with?

Bacterial Growth Curve



Changing the Bacterial Growth Curve



*Sub-optimal means lowered: pH, A_W, Temp., etc.

Killing Bacteria: D-Values

- A “D value” is the amount of time required to reduce the number of a certain bacteria by 90% at a specified temperature
- “D” comes from “decimal reduction”
  - e.g., how long to go from 10^6 *E. coli* O157:H7 to 10^5 *E. coli* O157:H7
    - This means there are 90% less *E. coli* O157:H7
  - A 2D reduction would be how long for: $10^6 \rightarrow 10^4$
    - This means there are 99% less *E. coli* O157:H7
  - A 3D reduction would be how long for $10^6 \rightarrow 10^3$
    - This means there are 99.9% less *E. coli* O157:H7
  - and so on…

- Application in canned/retorted foods
  - The 12D retort process
- Food Code examples:
  - Cooking temps for different foods
    - Based on expected pathogen loads (with *Salmonella* as a basis organism)
    - 165°F for 15 sec gives a 7D reduction
    - 155°F for 15 sec gives a 5D reduction
    - 145°F for 15 sec gives a 3D reduction
  - Sanitizing food contact surfaces
    - 5D reduction of pathogens (99.999%)

Potentially Hazardous Foods (PHF)

- *Definition*: A food that supports growth of infectious or toxin-producing microorganisms
  - These are the foods that have all the FAT TOM requirements for pathogen growth that we just discussed
- Examples of PHF's:
  - Raw or cooked foods of animal origin:
    - Meat, Poultry, Waterfoods, Eggs, Dairy Products
  - Some fruit and vegetables (F&V)

- Which F&V are PHF's?
  - Cut melons (like cantaloupe)
    - If intact, bacteria don't grow on outer surface
    - But, when cut, bacteria are "dragged" over cut surface
    - And the pH of some melons is >4.6
  - Heated/cooked fruits and vegetables
    - Rice, beans, baked potatoes, etc. after they are cooked
  - Minimally processed FF&V (i.e., bagged salads)
  - Seed sprouts (such as alfalfa sprouts)
  - Garlic in oil mixtures
- Could a non-PHF cause a foodborne illness?

Food Additives/Adulteration

- Additive
  - Government approved substances added to food during production or processing
  - Food processors add things to foods to make them taste and look better, help inhibit pathogen growth and increase shelf life (prevent microbial growth and chemical reactions)
- Adulterated
  - Adulterated food means one that contains poisonous ingredients, unapproved additives, or is composed of decomposed or unsanitary ingredients
  - **SEE Appendix 2 of the Food Code for the full definition of adulteration**

Some methods for prevention/ control of pathogens on foods

- Foodhandlers
  - Health
  - No bare hand contact with ready-to-eat foods
  - Hand washing
- Cleaning/sanitation of food contact surfaces
- Complete cooking
- Chlorine rinse of FF&V
- Proper hot/cold holding temps of PHF's
- Rapid and thorough chilling of leftover PHF's
  - Cool leftovers in small portions
- Approved Sources

Summary

- Food Spoilage
- Factors affecting microbial growth in foods
- Microbial growth (and death)
- Foods supporting microbial growth
- Food additives
- Prevention/Control of food pathogens